

**SYNOPSIS OF BIOLOGICAL DATA ON
INDIAN MACKEREL *Rastrelliger kanagurta* (CUVIER) 1817 AND
SHORT BODIED MACKEREL *Rastrelliger brachysoma* (BLEEKER) 1851**

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FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
Rome, 1965

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MAST	Information on methods and subjects.
OT	Oceanographic data.
IT	Limnological data.
CART	Information concerning fisheries and resources of certain countries and regions (FID/S).

Des catégories spéciales d'études synoptiques sont identifiées à l'aide de symboles suivis des chiffres de classification basés sur le code d'indexation de la « Current Bibliography »:

SAST	Données sur certaines espèces et populations de poissons.
MAST	Renseignements sur des méthodes et des sujets.
OT	Données océanographiques.
IT	Données limnologiques.
CART	Renseignements sur les pêcheries et les ressources de certains pays et régions (FID/S).

Grupos especiales de sinopsis se distinguen con las siglas siguientes, seguidas por números de clasificación que se basan en las claves de los índices de la « Current Bibliography »:

SAST	Datos relativos a ciertas especies y poblaciones.
MAST	Sinopsis sobre métodos y materias.
OT	Sinopsis sobre oceanografía.
IT	Sinopsis sobre limnología.
CART	Información sobre los recursos acuáticos vivos de algunos países y regiones (FID/S).

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MFS	Provisional editions of "FAO Manuals in Fisheries Science."

Some documents also have another identification, if, for example, they have been contributed to a meeting for which papers have been numbered according to another system.

Des catégories spéciales de documents techniques sont identifiées à l'aide des symboles suivants:

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CB	Listes de périodiques, des sections spéciales de la « Current Bibliography for Aquatic Sciences and Fisheries », des bibliographies particulières et des articles sur les problèmes de documentation.
MFS	Editions provisoires des « Manuels FAO de la science des pêches ».

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E R R A T A

<u>Location</u>	<u>For</u>	<u>Read</u>
Section 2.3, last but two lines	"Rastrelliger	" <u>Rastrelliger</u>
Section 3.1. Under paragraph Heterosexual. third line	Prabhu and Antony Raja 1959, and Thomas and Raju 1964)	(Prabhu and Antony Raja 1959, and Thomas and Raju 1964)
Section 3.4.2 Food (type, volume) 2nd paragraph 4th line	<u>discus, Dinophysis</u> <u>peridinium, pleuro-</u>	<u>discus, Dinophysis,</u> <u>Peridinium, Pleuro-</u>

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SYNOPSIS OF BIOLOGICAL DATA ON INDIAN MACKEREL

Rastrelliger kanagurta (Cuvier) 1817

and

SHORT BODIED MACKEREL Rastrelliger brachysoma (Bleeker) 1851

Prepared by

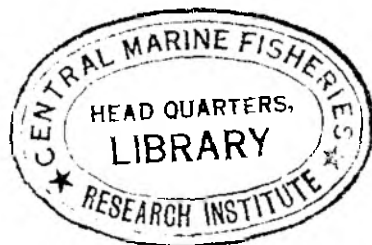
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PREPARATION OF THIS SYNOPSIS

This is an unabridged, revised version of the first draft prepared by H. Rosa Jr. for the Meeting of the Indo-Pacific Fisheries Council Sub-Committee on Rastrelliger, Malaya, September, 1956. Appendix 7 (IV) of Summary Record of the Sub-Committee Meeting, "Synopsis of data on the species of the genus Rastrelliger Jordan and Starks 1908")

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Reviews information on taxonomy, distri-
bution, bionomics and life history, popu-
lation, and exploitation. Incl. compre-
hensive bibliography on the subjects
reviewed.

C O N T E N T S

	<u>Page no.</u>
1	IDENTITY 1:1
1.1	<u>Taxonomy</u> 1
1.1.1	Definition 1
1.1.2	Description 1
1.2	<u>Nomenclature</u> 1
1.2.1	Valid scientific names 1
1.2.2	Synonyms 1
1.2.3	Standard common names, vernacular names 7
1.3	<u>General variability</u> 9
1.3.1	Subspecific fragmentation (races, varieties, hybrids) 9
1.3.2	Genetic data (chromosome number, protein specificity)*
2	DISTRIBUTION 2:1
2.1	<u>Delimitation of the total area of distribution and ecological characterization of this area</u> 1
2.2	<u>Differential distribution</u> 1
2.2.1	Areas occupied by eggs, larvae and other junior stages: annual variations in these patterns, and seasonal variations for stages persisting over two or more seasons 1
2.2.2	Areas occupied by adult stages, seasonal and annual variations of these 3
2.3	<u>Behaviouristic and ecological determinants of the general limits of distribution and of the variations of these limits and of differential distribution</u> 3
3	BIONOMICS AND LIFE HISTORY 3:1
3.1	<u>Reproduction</u> 1

	<u>Page no.</u>
3.1.1 Sexuality (hermaphroditism, heterosexuality, intersexuality)	3:1
3.1.2 Maturity (age and size)	1
3.1.3 Mating (monogamous, polygamous, promiscuous)	1
3.1.4 Fertilization (internal, external)	1
3.1.5 Fecundity	
- Relation of gonad size and egg number to body size and to age	1
- Coefficient of fecundity	4
3.1.6 Spawning	4
- Spawning seasons (beginning, end, peak)	4
- Number of spawnings per year, frequency	4
- Spawning time of day*	
- Induction of spawning, artificial fertilization*	
3.1.7 Spawning grounds	4
- Coastal (surface, vegetation, shore, shoal, sand, shelter); bottom*	
- Oceanic (surface, bottom)	4
3.1.8 Egg: structure, size, hatching type, parasites, and predators	4
3.2 Larval history	4
3.2.1 Account of embryonic and juvenile life (prelarva, larva, postlarva, juvenile)	4
- Feeding	4
- Rates of: development and survival*	
- Periods of: development and survival*	
- Parental care*	
- Parasites and predators*	
3.3 <u>Adult history</u>	4
3.3.1 Longevity	4
3.3.2 Hardiness	4
3.3.3 Competitors	4
3.3.4 Predators	4
3.3.5 Parasites and diseases	4
3.3.6 Greatest size	4
3.4 <u>Nutrition and growth</u>	4
3.4.1 Feeding (time, place, manner, season)	4
3.4.2 Food (type, volume)	5
3.4.3 Relative and absolute growth patterns and rates*	

	<u>Page no.</u>
3.4.4 Relation of growth to feeding, to other activities, and to environmental factors*	
3.5 <u>Behaviour</u>	3:6
3.5.1 Migration and local movements	6
3.5.2 Schooling	6
3.5.3 Reproductive habits	6
4 POPULATION (STOCK)	4:1
4.1 <u>Structure</u>	1
4.1.1 Sex ratio	1
4.1.2 Age composition	1
4.1.3 Size composition	1
4.2 <u>Size and density</u>	1
4.2.1 Average size	1
4.2.2 Changes in size	2
4.2.3 Average density*	
4.2.4 Changes in density*	
4.3 <u>Natality and recruitment*</u>	
4.3.1 Natality*	
4.3.2 Natality rates*	
4.4 <u>Mortality, morbidity*</u>	
4.4.1 Rates of mortality*	
4.4.2 Factors or conditions affecting mortality*	
4.4.3 Factors or conditions affecting morbidity*	
4.4.4 Relation of morbidity to mortality rates*	
4.5 <u>Dynamics of population*</u>	
4.6 <u>Relation of population to community and ecosystem, biological production, etc.*</u>	
5 EXPLOITATION	5:1
5.1 <u>Fishing equipment</u>	1

coast of Sumatra.

Japan

Neighbourhood of the Ryukyu Islands.

Philippines

The principal fishing areas of young and adult *R. kanagurta* are: eastern and northwest Palawan and vicinities; north-east Palawan, including Cuyo group; southern Zamboanga and Sulu Archipelago; Visayan Sea, and of *R. brachysoma*: Manila Bay, Ragay Gulf, Southwest Samar, Estancia, Iloilo, Gigantes and Bantayan Islands, northern Negros, Malampaya Sound and vicinity; Pantao and Malakbala, Albay Province; Mercedes, Camarines Norte.

5.2.3 Depth ranges

Mackerel fishery is usually confined to inshore waters but fish have been recorded in the trawl catches off Bombay and Saurashtra coasts, in November and December during the 1961-1962 season. A survey by R.V. VARUNA in the Mangalore-Calicut zone in February 1962 revealed traces of shoals in waters up to 20 m depth but not beyond.

Generally, the changes in depth at which mackerel are caught depend on the nature of coastline, the time or season of fishing and the type of net operated. The depth may vary from 2 to 12 fathoms or even more. Mackerel were caught in even deeper waters off Porbandar in trawl operation. Along the Kanara and Konkan coast up to Ratnagiri, where the bottom of inshore waters is sandy or muddy, the shore-seine-Rampan net is operated in 2-4 fathoms or within a range of a mile and a half. During the rainy season a smaller shore-seine is operated in one or two fathoms. Gill nets and boat-seines on the Malabar coast in particular, are not usually operated so close to the shore or in shallow waters.

5.3 Fishing seasons

5.3.1 General pattern of fishing season

The mackerel season depends on the concentration of shoals in inshore waters where they are intercepted and caught.

5.3.2 Duration of fishing season

Chidambaram and Venkataraman (1946) state that the Indian mackerel fishery on

the west coast of India extends from September to April, prior to the outbreak of the southwest monsoon. At Karwar and along the Kanara coast as indicated by Pradhan (1956) it is from October to February and may, at times, extend to March. The mackerel shoals subsequently break up, resulting in poor catches in April, and practically disappear from the shores of Karwar during May. In the rainy season, June to end of September, they are occasionally caught in small numbers in inshore waters within a range of about half a mile from the shore. Thus the duration of fishing season may vary from coast to coast. On the Malabar coast, it may be 5-7 months and on the Kanara and Konkan coast up to Ratnagiri 4-6 months.

5.3.3 Dates of beginning, peak and end of season

India

On the Malabar coast, the season begins in August-September, with a peak in November-December and ends in February or March. On the Kanara and Konkan coasts, it may begin some time in October with a peak in November-December, closing abruptly in February-March. A secondary peak of a short duration was noted towards the end of the season, February-March on the west coast.

Cambodia

As indicated by Durand (1949) the mackerel appears on the coast towards the end of October in the neighbourhood of the Bay of Kampong-Som; a month later near Cone Island and Kaskapik. It remains there until February, a period when the females are ripe and ready to spawn.

Philippines

See Tables VII and VIII.

Ceylon

Large shoals of *R. kanagurta* normally occur on the west coast of Ceylon where they are caught in considerable numbers in the beach seine in the November-February period, and on the east coast almost throughout the year, with peaks in September and December-April. Catches of the inshore species are highest on the south coast in the December-February period.

Table VII
Principal fishing areas and seasons of the
young and adult "hasa-hasa" (R. brachysoma)
(Philippines)

Fishing Areas	Fishing Young	seasons Adult
Manila Bay	Throughout the year	May to December
Ragay Gulf	March to September	December to May
Southwestern Samar	November to January	February to May
Estancia Iloilo	March to June	May to October
Gigantes and Bantayan Islands	March to May	April to October
Northern Negros	May to June	June to August
Malampaya Sound and vicinity	April to May	May to September
Pantao and Malakbala, Albay Province	April	October to May
Mercedes, Camarines Norte		May to September

Table VIII
Principal fishing areas and seasons of the
adult "alamahan" (R. kanagurta)
(Philippines)

Fishing areas	Fishing season
Eastern and northwestern Palawan and vicinities	December to June
Northeastern Palawan, including Cuyo group	April to November
Southern Zamboanga and Sulu Archipelago	December to May
Visayan Sea	April to October

	<u>Page no.</u>
5.1.1 Fishing gear	5:1
5.1.2 Fishing boats	1
5.2 <u>Fishing areas</u>	1
5.2.1 General geographic distribution	1
5.2.2 Geographical ranges (latitudes, distances from coast, etc.)*	
5.2.3 Depth ranges	4
5.3 <u>Fishing seasons</u>	4
5.3.1 General pattern of fishing season	4
5.3.2 Duration of fishing season	4
5.3.3 Dates of beginning, peak and end of season	4
5.3.4 Variation in time or duration of fishing season	6
5.3.5 Factors affecting fishing season	6
5.4 <u>Fishing operations and results</u>	6
5.4.1 Effort and intensity*	
5.4.2 Selectivity*	
5.4.3 Catches	6
5.5 <u>Fisheries management and regulations*</u>	
5.6 <u>Fish farming, transplanting and other intervention*</u>	
6 REFERENCES	6:1

*As no information was available to the author, these items are not listed in the text.

1 IDENTITY

1.1 Taxonomy1.1.1 Definition

Phylum Vertebrata
 Subphylum Craniata
 Superclass Gnathostomata
 Series Pisces
 Class Teleostomi
 Subclass Actinopterygii
 Order Perciformes
 Suborder Scombroidei
 Superfamily Scombroidae
 Family Scombridae
 Genus Rastrelliger
 Jordan and Starks 1908
 Species: Rastrelliger
kanagurta (Cuvier) 1817;
Rastrelliger brachysoma
 (Bleeker) 1851

Jordan and Hubbs (1925) place the genus Rastrelliger under a separate subfamily Rastrelligerinae while they include only Scomber and Pneumatophorus under the subfamily Scombrinae.

1.1.2 Description

- Genus Rastrelliger
 Jordan and Starks
 1908 Proc. U.S. Nat.
 Mus. 54 : 607 (Type:
Scomber kanagurta
 Cuvier 1817)

The genus Rastrelliger is described by Jones and Silas (1964a) as follows: "Body compressed from side to side; body and cheek covered with small scales, eyes with well developed adipose eyelid, mouth large, maxillary reaching nearly vertical below posterior edge of eye; teeth small, present in jaws; vomer and palatine edentulous; gill rakers long, numerous and feather-like and visible when mouth is opened. Spinous first dorsal and soft rayed second dorsal separated by distance equalling length of base of former; anal devoid of spines; five or six dorsal and anal finlets; pectorals short with broad base; pelvics with spine and 5 rays; caudal deeply forked".

Distribution: Tropical Indian and West Pacific Oceans from the east coast of South Africa to North Australia and as far as Micronesian and Polynesian Islands.

1.2 Nomenclature1.2.1 Valid scientific names

De Beaufort (1951) lists three species of Rastrelliger but Jones and Silas (1964a, 1964b) recognise only two species viz., R. kanagurta (Cuvier) 1817 and R. brachysoma (Bleeker) 1851 whereas the third species viz., R. neglectus for reasons stated in Jones and Silas (1964b) is relegated as a synonym of R. brachysoma. They give the following distinguishing characters for the two species.

Length of head distinctly greater than depth of body; latter 23 percent to 27 percent in fork length; snout pointed; dark stripes or rows of dusky spots along upper half of body; outer margin of first dorsal dusky.

Rastrelliger kanagurta (Cuvier)
 (Fig. 1a)

Length of head distinctly shorter than depth of body; latter 28.5 percent to about 34 percent in fork length; snout short and bluntly rounded; no dark stripes or regular rows of dusky spots along upper half of body; outer margin of first dorsal black.

Rastrelliger brachysoma (Bleeker)
 (Fig. 1b)

For differences in gill rakers see Fig. 2a and 2b and for morphometric variations see Fig. 3.

1.2.2 Synonyms

Rastrelliger kanagurta (Cuvier) 1817

Scomber kanagurta Cuvier 1817

Scomber canagurta Cuvier 1829

Scomber kanagurta Cuvier and Valenciennes 1831

Scomber chrysosoma Rüppell 1835

Scomber microlepidotus Rüppell 1835

Scomber moluccensis Bleeker 1856

Scomber reani Day 1870

Scomber lepturus Agassiz 1874

Rastrelliger brachysomus (nec.

Bleeker) Jordan and Dickerson 1908

Rastrelliger kanagurta Jordan and

Starks 1917

Rastrelliger chrysozonus Kishinouye 1923

Rastrelliger serventyi Whitely 1944

Rastrelliger brachysoma (Bleeker)
 1851



Figure 1a. Rastrelliger kanagurta (Cuvier)
from the West Coast of India



Figure 1b. Rastrelliger brachysoma (Bleeker) from
Andamans (Reproduced from Jones and Silas 1964b)

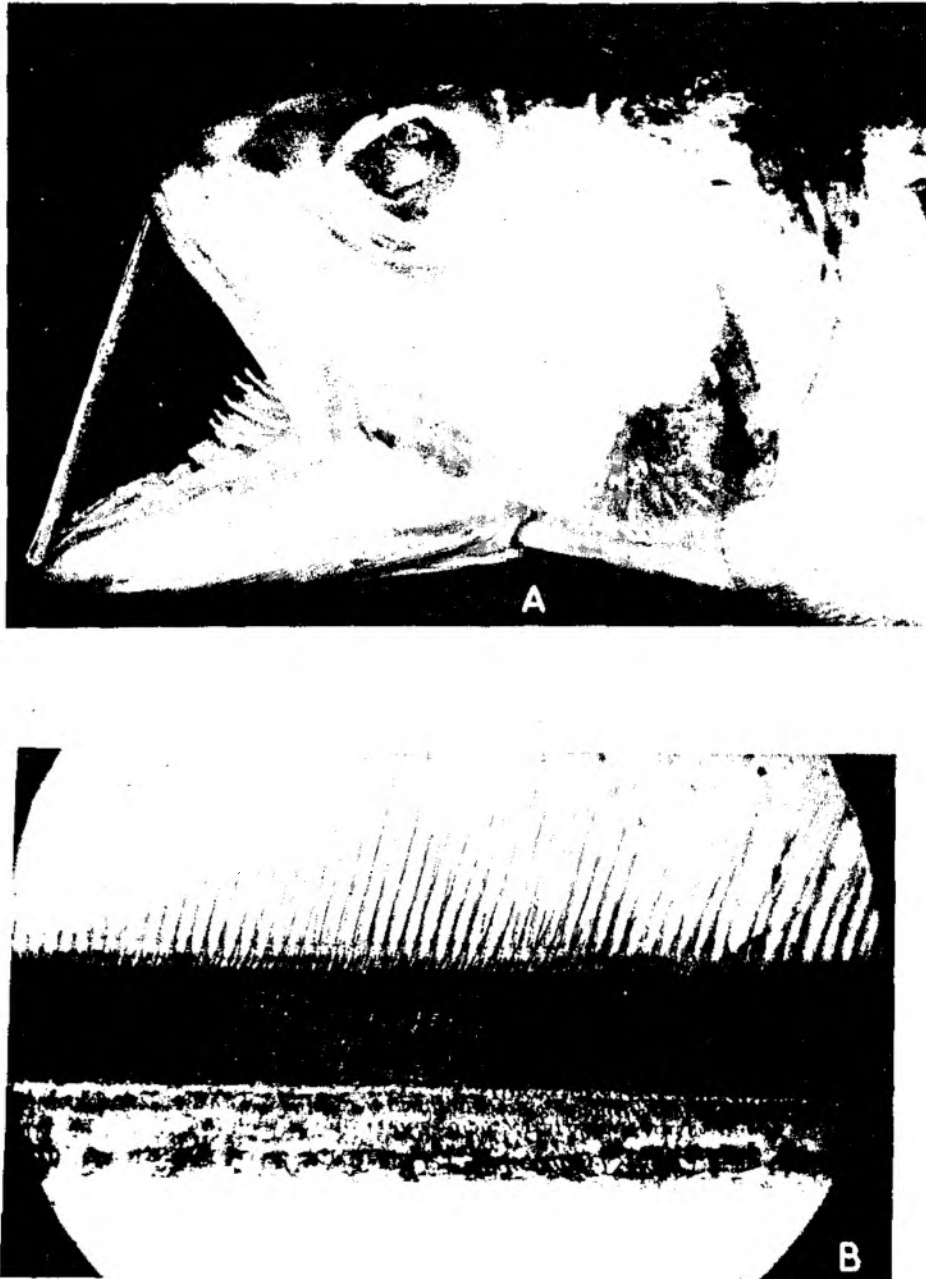


Figure 2a. Rastrelliger kanagurta (Cuvier): (A) Mouth of 26.8 cm specimen kept open to show the relatively less exposed gill rakers. (B) Part of longest gill raker on the lower limb of the outer gill arch of the same showing the dense pigmentation and the relatively shorter simple branches. (Reproduced from Jones and Silas 1964b)

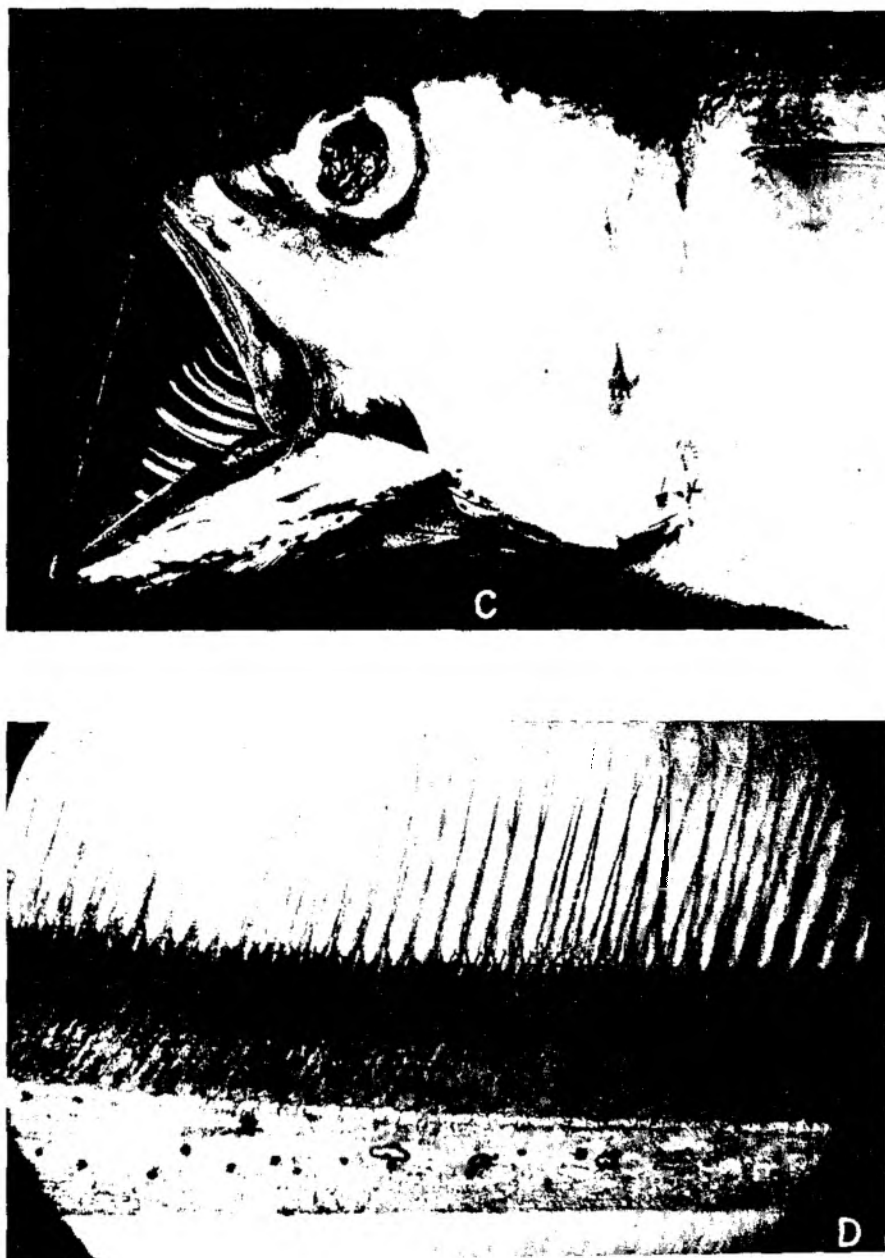
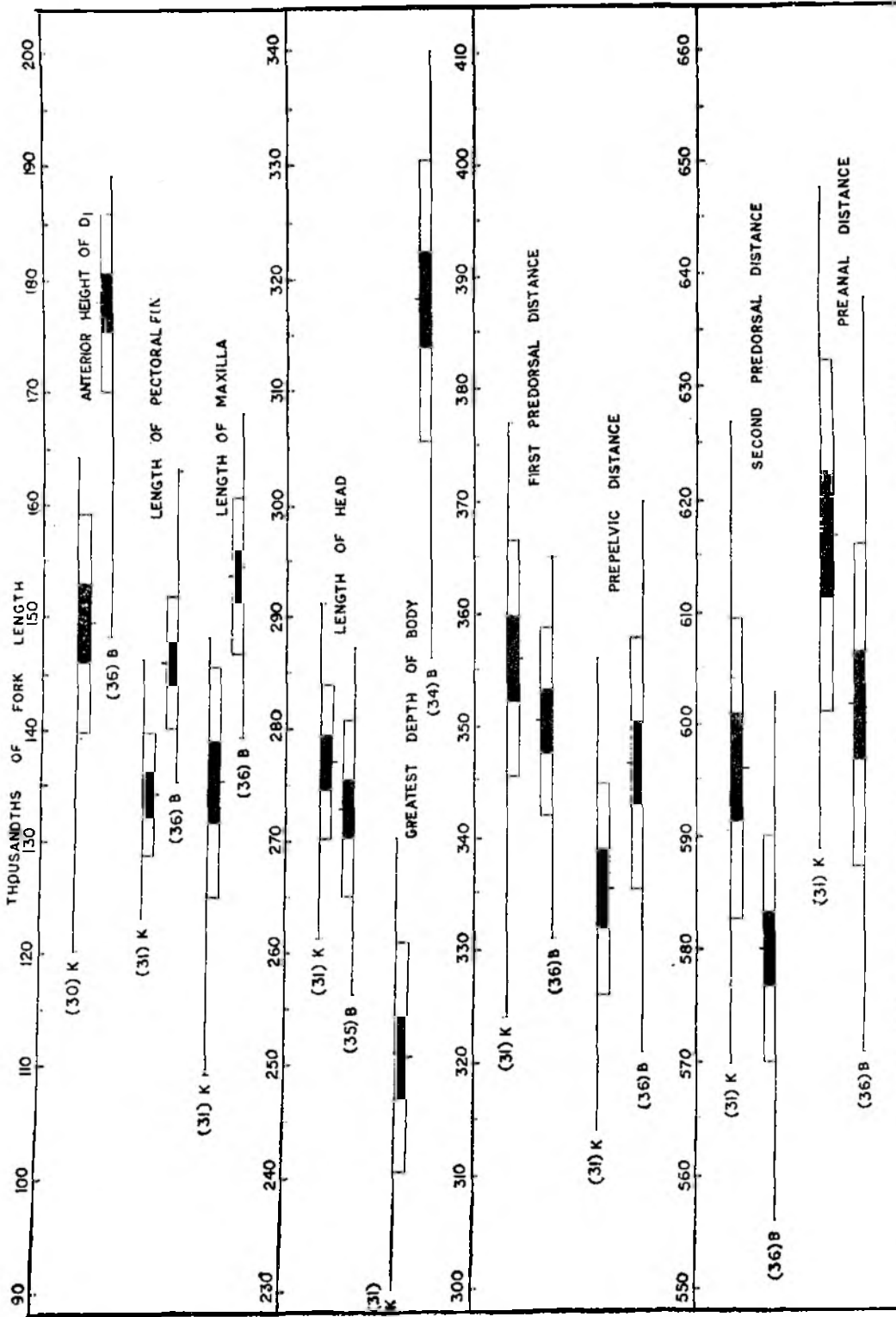


Figure 2b. Rastrelliger brachysoma (Bleeker): (C) Mouth of 21.3 cm specimen kept open to show the long feather-like exposed gill rakers. (D) Part of the longest gill raker of the same species showing the sparse pigmentation and the relatively longer simple branches. (Reproduced from Jones and Silas 1964b)



K = RASTRELLIGER KANAGURTA (CUVIER) B = RASTRELLIGER BRACHYSOMA (BLEEKER)

Figure 3. Graph showing variations in 9 characters in two samples of *R. kanagurta* and *R. brachysoma* from Andaman Sea. (The horizontal line represents the total range; the short vertical line the mean; the solid rectangle two standard errors on each side of the mean and the hollow rectangle one standard deviation on each side of the mean. The number of specimens in each sample is given in parenthesis). (Reproduced from Jones and Silas 1964b)

Scomber brachysoma Bleeker 1851
Scomber neglectus Van Kampen 1907
Rastrelliger brachysomus Barnard
 1927

1.2.3 Standard common names,
 vernacular names

Table I
 Common names

Country	R. brachysoma		R. kanagurta	
	Language or Dialect	Vernacular Name	Language or Dialect	Vernacular Name
Cambodia		Ca bao ma Plathu		Ca bac ma, Ca be lau, Trey kamong, Ca nung nuc
Indonesia		Kembung perempuan		Kembung, Banjar, Kembunglelaki
Philippines		Short-bodied mackerel Chub mackerel		Striped mackerel, Chub mackerel
	Tagalog	Kabalyas	Tagalog	Alumahan, Lumahan
	Bikol	Aguma -a Kabalyas	Bikol	Burau
	Kuyano and Tagbanwa	Luman	Kuyano and Tagbanwa	Salimburaw
	Pampango	Asa-asa	Ilokano	Bunatan
	Visayan	Aguma-a	Pangasinan	Kabalyas
	Visayan Banton	Hasa-hasa	Visayan Banton	Buyaw
	Tagalog	Hasa-hasa Linchay (Immature) Masangi, Tulay	Ilokano	Mataan
				Hasa-hasa Mataan
	Burma			Indian mackerel
Ceylon			Indian mackerel	
			Sinhalese	Kumbalava, Maha kara bolla
			Tamil	Ailai, Karung kuluttan, kumbala
Malaysia (States of Malaya) (Singapore)				Kuala muda, Kedah, Kembong
		Kembong		Kembong Indian mackerel
India			Canarese	Bangada
			Marathi	Kaula gedar
			Malayalam	Ayila
			Sindhi	Oibia gedar

Table 1 (contd)

Country	<u>R. brachysoma</u>		<u>R. kanagurta</u>	
	Language or Dialect	Vernacular Name	Language or Dialect	Vernacular Name
India (contd)	Tamil			Ailai, Kuria, Kanangeluthi
	Telugu			Kanagurta, Kaman- gadachalu, Kannan- gadatha, Vahjiramu
				Karan Kita
Japan				Gurukunmuchji, Naha, Agifurakiya
Saudi Arabia				Bagha
Thailand				Pla - thu, Tu
Somalia	Mij			Bagha
	Kism			Burei
	Baj			Garmu, Nuna
Pakistan West				Surmai

1:3 General variability

1.3.1 Subspecific fragmentation (races, varieties, hybrids)

Racial studies on Rastrelliger have been made in the Philippines and India but have not resulted in any tangible conclusions. A critical study of R. kanagurta and R. brachysoma of Andaman Sea by Jones and Silas (1964b) is perhaps the most significant contribution in this line and might serve as a preliminary lead for the taxonomic studies on this genus.

2 DISTRIBUTION

2.1 Delimitation of the total area of distribution and ecological characterization of this area (Fig. 4)R. brachysoma - Tropical Indo-Pacific

- Indian Ocean: Occasionally found in waters of South Africa, around Durban; Andaman Islands.

- Central Indo-Pacific: Malaysia (Federation of Malaya, Singapore, Sarawak and Sabah); Thailand; Philippines; Indonesia; New Guinea; Fiji and Solomon Islands.

R. kanagurta - Tropical Indo-Pacific

- Indian Ocean: Persian Gulf; Somalia; Seychelle Islands; Mozambique in Delagoa Bay; Coast of South Africa around Durban; Pakistan; coasts of India, Andaman and Nicobar Islands; Ceylon; Burma.

- Central Indo-Pacific: Malaysia (Federation of Malaya, Singapore, Sarawak and Sabah); Thailand; Cambodia; Philippines; Indonesia; Australia along the coast of Queensland; New Guinea; widely distributed in Melanesia, Micronesia and Polynesia area and reported from the islands of Bougainville, Solomon, New Hebrides, Fiji, Samoa and others; coast of Peoples Republic of China, Taiwan, Hong Kong, Ryukyu Islands and Hawaiian Islands.

2.2 Differential distribution

2.2.1 Areas occupied by eggs, larvae and other junior stages: annual variations in these patterns, and seasonal variations for stages persisting over two or more seasons

- Eggs:

Information available on the eggs and their distribution is very fragmentary and hardly confirmatory. They, as in other scombroids, should be pelagic and the species, not being oceanic, spawning should take place in waters within the continental shelf. The earliest reference to eggs of Rastrelliger kanagurta is by Delsman (1926) from the Java Sea, but subsequently, he expressed doubts (Delsman 1931) on

their identity and suggested that they could belong to Thunnus thunnina (Euthynnus affinis).

It has been recorded in the Administrative Report of the Madras Fisheries Department (1937) that eggs suspected to be those of mackerel were obtained from plankton collected off West Hill, Calicut. Devanesan and John (1940) recorded the collection of 405 eggs in different stages of development on 5 June 1937, five miles from the shore off Chaliyam, south of Calicut on the west coast of India.

Balakrishnan (1957) says that "Hauls made in the 18 - 25 fathom area off Vizhingam during all the months from March to May showed a few eggs of 0.84 - 1.009 mm diameter which are tentatively assigned to mackerel". No figures or description of eggs are available.

- Larvae:

Kuthalingam (1956) refers to the collection of postlarvae measuring 5 mm to 6 mm which "resembled the juveniles in general form and were collected mainly from the plankton samples brought to the laboratory". No figures or descriptions are available.

The only reference to the very early larvae of the Indian mackerel is the following statement of their occurrence off Vizhingam on the Kerala coast. "Plankton hauls made on 23 May 1956 on the spot where the fishermen were engaged in fishing showed prelarvae measuring 2.8 mm and 5 mm" (Balakrishnan 1957). However, no figures or descriptions are given. It may be stated here that 5 mm appears to be too large a size to be prelarva.

- Juveniles:

For occurrence and distribution of juveniles see Table 2.

The records of juveniles hitherto have been from coastal waters caught in shore seines along with other fishes. Often commercial catches of mackerel are constituted of juveniles only.

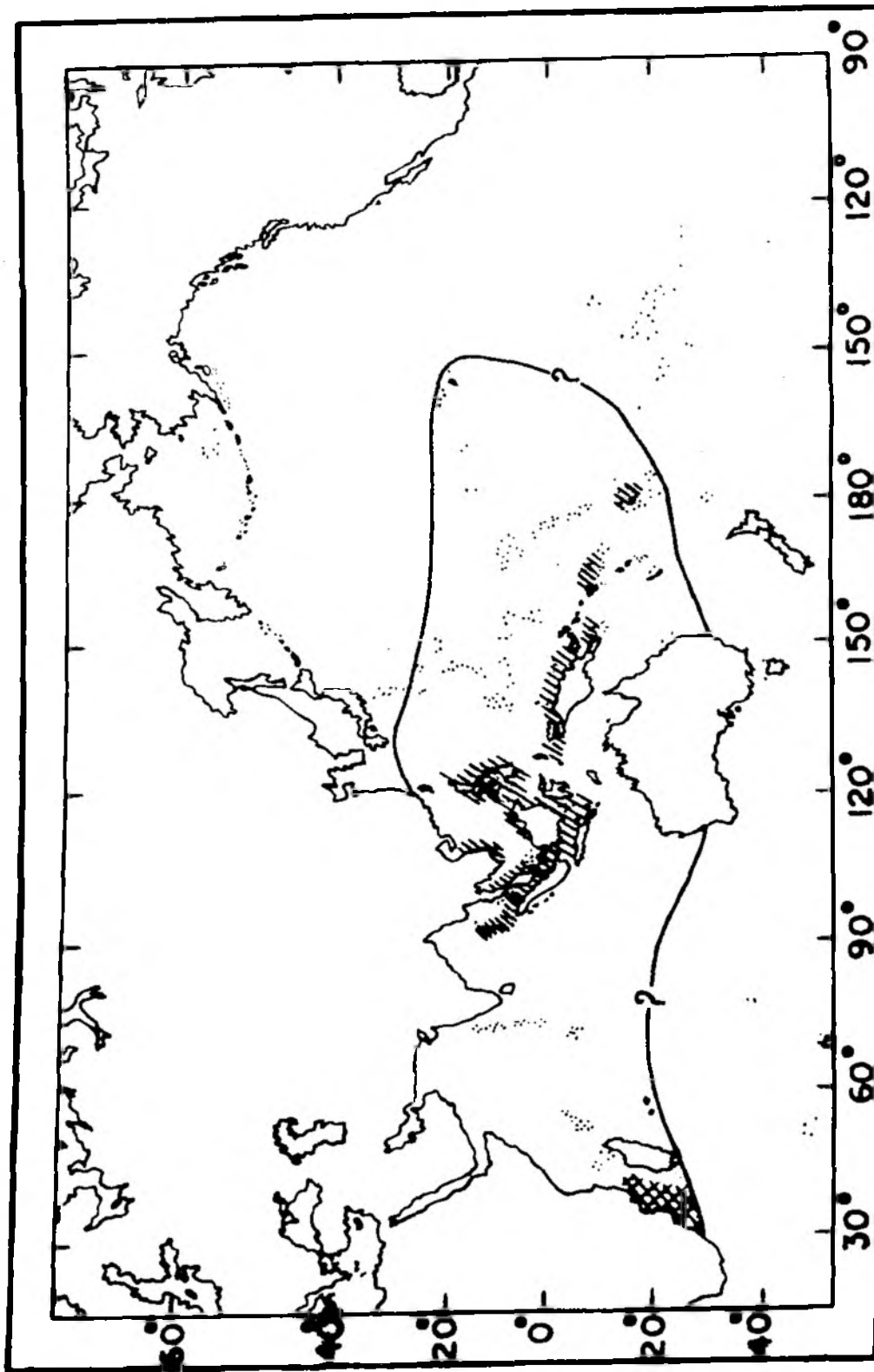


Figure 4. World distribution of fishes of the genus Rastrelliger

— Distribution of Rastrelliger kanagartha

/// Distribution of Rastrelliger brachysoma

xxx Rastrelliger brachysoma, doubtful occurrence

Table II
Occurrence of Juveniles

Locality	Author
<u>India - West Coast</u>	
Ratnagiri	George and Annigiri 1960
Karwar	Pradhan 1956
Mangalore	Rao 1964
Calicut	Madras Fisheries Administrative Report, 1940, Bhimachar and George, 1952, Quarterly Scientific Reports of the Central Marine Fisheries Research Institute, June-December 1961
Cochin/Ernakulam	Rao 1964
Vizhingam	Balakrishnan 1957, Jones and Kumaran 1964
<u>- East Coast</u>	
Madras	Rao and Basheeruddin 1953, Kuthalingam 1956, Basheeruddin and Nayar 1962
Lawson's Bay	Satyanarayana as cited by Rao 1964
Visakhapatnam	Rao and Basheeruddin 1953, Rao and Rao 1957
Andaman Sea near Port Blair	Rao 1964
<u>Ceylon - South Coast</u>	de Zylva 1956

2.2.2 Areas occupied by adult stages, seasonal and annual variations of these

Records so far have been from coastal waters from within the continental shelf. On the west coast of India it is found practically all the year round, the main season being from August to March. Mackerel were recorded in the trawl catches off Bombay and Saurashtra coasts during the 1961-1962 season. Along the coast of Ceylon and on the east coast of India it is caught in stray numbers. Catches are not high in the Andaman Seas but little is known about the fishery resources of this area since there is

only very restricted fishing activity there. Both species occur along the Malayan and Indonesian coasts but R. kanagurta is dominant. In the Philippines both species occur in coastal waters and here also R. kanagurta appears to be dominant.

2.3 Behaviouristic and ecological determinants of the general limits of distribution and of the variations of these limits and of differential distribution

Hardenberg (1955) states: "Rastrelliger species are pelagic moving in schools, whose size is determined probably by local conditions

in sea. There are at least two species forms or races, one an oceanic form and the other a more neritic one. How far the oceanic form ventures out at sea is not known at present, or at least has not yet been published. So it is not yet certain whether this oceanic form, or species, is found so far away from the nearest coast as for instance the true Atlantic mackerel. It is still not certain therefore whether they occur in quantities more than 50-60 nautical miles from shore, which is about the limit for practical fisheries in the countries most concerned with Rastrelliger fisheries.

"The neritic form lives in shallow water, often of depth not more than 15 m at least according to my own experience. It is probable, however, that depth is not the only determining factor. Hydrological conditions will have something to do about it too. The neritic form seems to prefer a muddy or clayish bottom, but whether this always holds true I cannot say. Clear water of a salinity of more than 32.5‰ seems to be avoided. So are the vicinities of coral reefs. On the other hand a muddy sea is avoided too. The exact degree of silt turbidity avoided is thus far unknown.

"The oceanic form lives in the clear waters of the open sea with a salinity of 32‰ and more and it seems at least in the Java Sea - that a depth of 20 m and more is preferred. I have often found a kind of no-mansland between the two forms. Indonesian fishermen often maintain that the oceanic mackerel prefers a sandy bottom. This is certainly not always true."

Manacop (1956) states that R. brachysoma is evidently a coastal or inshore form feeding mainly on microplankton, and R. kanagurta is apparently an open sea form and feeds mainly on macroplankton such as larval shrimps and fishes.

Pradhan (1956) writes that "Records show that mackerel can withstand low salinities even down to 2.04‰."

According to Pradhan and Gangadhar Reddy (1962) "increase in temperature and salinity has been found to effect mackerel catches adversely, whereas their low values exerted a less pronounced effect. Mackerel appears to be more susceptible to changes in temperature than salinity and the tolerance ranges of these factors seem to depend on the size of the fish. Large fish (19-21 cm) appear to

tolerate increase in temperature and salinity whereas smaller fish usually occur in large numbers from June to September (at Calicut) when low levels of temperature and salinity prevail. One of the criteria for a good mackerel season may be the degree of variation of temperature and salinity should be within the tolerance ranges of these two hydrographical factors. High pH may have an added adverse effect on the fishery. Probable effects of wind force and rainfall on the fluctuations in mackerel landings at Calicut are also briefly considered.

"Mackerel are known to enter estuarine waters of Kali river and ascend along the tidal current up to a distance of about 1 1/2 miles during April and May when the range of salinity of river water is between 29.73 and 34.6‰."

Mackerel have also been recorded in Netravati estuary and Cochin backwaters.

The species of the genus Rastrelliger is distributed only in the tropical Indo-west-Pacific faunistic region. It does not go eastward to the East-Pacific Barrier.

The faunistic region is characterized by:

1. The occurrence of reef building corals.
2. The fish fauna of the shelf of the region is very much richer in species than that of the rest of the main tropical regions.

Oceanographically, the distribution coincides with the Indo-Pacific equatorial current regions. In general, these regions are characterized by:

1. High temperature of the surface waters, (the distribution of Rastrelliger is inside the area where the temperature at 200 m depth is 15°C or where the surface temperature does not fall below 17°C in any season).
2. Predominant east-westerly surface currents.
3. Medium basic organic production.
4. Relatively low degree of seasonal variations.

The natural regions where Rastrelliger is distributed can be grouped into four

and characterized on the basis of similarity. (Rosa 1962) The general characteristics of the groups are the following:

Group I - Monsoon regions -

- (1.1 Arabian Sea region,
- 1.2 Bay of Bengal region,
- 4,7,1 South China Sea with
Malayan Archipelago)

1. Relatively large continental shelf.
2. Monsoon winds.
3. Medium to high precipitation and runoff.
4. Surface temperatures of 20-30°C.
5. Surface currents changing with the change of monsoons.
6. Seasonal variations; medium.
7. Basic organic production; medium to low.
8. Presence of subsurface O₂ minimum layer.

Group II - Equatorial current regions
North and South

- (1.3 Indian Ocean North Equatorial Current region
- 4 Pacific North Equatorial region,
- 1.5 Indian South Equatorial Current region
- 4.9 Pacific South Equatorial current region)

1. Very small continental shelves; mainly deep oceanic areas.
2. Trade winds (except in 1,3 which is influenced by monsoons).
3. Medium precipitation, low runoff.
4. Surface temperatures 25 - 28°C.
5. Easterly surface currents.
6. Low degree of seasonal variations.
7. Low organic production.

5 BIONOMICS AND LIFE HISTORY

3.1 Reproduction

3.1.1 Sexuality (hermaphroditism, heterosexuality, intersexuality)

Heterosexual. Instances of hermaphroditism recorded in Indian mackerel (Prabhu and Antony Raja 1959, and Thomas and Raju 1964).

3.1.2 Maturity (age and size)

The minimum size at maturity in India has been found to be 20 cm by Chidambaram and Venkataraman (1946) and 22.4 cm by Pradhan (1956). The fish is known to attain a length of 19 - 21 cm at the end of the second year. It is possible to distinguish sex in fish about 12 cm total length.

It has been indicated that there is a decrease in the rate of growth after a certain length (standard) has been reached and it has been suggested that the point of inflexion on the growth curve indicates the length at which full maturity is attained.

At Calicut in the 1955-1956 season 44 percent of the spawners belonged to 23 cm size group and another 27 percent composed of 24 cm size group. At Karwar male specimens were in oozing condition in July and females in stages V and VI (see Tables III and IV). During the 1956-1957 season juvenile mackerel were encountered at Waltair in all months except February 1957. At Vizhingam the spawners were in the size 24 - 27 cm. In the 1957-1958 season stages IV, V and VI were recorded at Karwar during July - August. During January-March period large mackerel about 23 cm in partially spent, spent and recovering stages were recorded at Mangalore (Netravati estuary). At Vizhingam females with the ovary in "plum-pudding" stage were collected on 27 and 28 May. Males oozing milt under pressure were also recorded. Observations at Karwar during the 1958-1959 season indicate that one spawning period is likely from May or June to January or February, with a rather short time interval in the ripening of successive batches of ova. At Karwar during the 1959-1960 season the majority of fish above 22 cm were in spent condition. At Ernakulam fish in stage IV and spent condition were recorded in March, April and May. During

the 1960-1961 season one spent female with a few large residual eggs in the ovary was recorded in March at Ernakulam. A few oozing females were collected at Porto Novo from night catches beyond the 10 fathom line. During the 1961-1962 season one specimen at Karwar on 4.8.1961 showed developing "plum-pudding" ovary with transparent ova.

Sexual maturity studies indicate that in Manila Bay Rastrelliger brachysoma of both sexes mature at a minimum size range of 15.0 - 15.9 cm. In the range 16.0 - 16.9 cm, all fish examined of both sexes were invariably mature.

Rastrelliger kanagurta from Northern Palawan, on the other hand, matures in the minimum size range of 21.0 - 21.9 cm and attains a maximum size range of 24.0 - 24.9 cm. (Philippines Fisheries Handbook 1952).

3.1.3 Mating (Monogamous, polygamous, promiscuous)

Polygamous.

3.1.4 Fertilization (internal, external)

External.

3.1.5 Fecundity

- Relation of gonad size and egg number to body size and to age

A key has been prepared by Pradhan and Palekar (1956) to help in the interpretation of the maturity stages of the gonads, male and female, of the Indian mackerel. The maturity scales used by the International Council for the Exploration of the Sea for herring has been adopted up to Stage V inclusive. (Wood 1930) The Stage VI was divided into Stage VI (a) and (b) due to peculiar ripening of ova in batches giving an appearance to the ovary described as "plum-pudding stage".

The key is reproduced excluding the description of the general appearance of the ovary and testes, and appearance of ova under the microscope.

Table III
Key to the stages of sexual maturity of
the female Indian mackerel (Rastrelliger kanagurta)
(Pradhan and Palekar, 1956)

Extent of ovary in the body cavity	Range of ova	State of maturity ^{1/}	Maturity stage
Ovary less than half the length of the body cavity	0.038-0.13 0.14-0.27	Im	I
Ovary slightly more than half the length of the body cavity	0.28-0.37	m	II
Ovary extending to about 2/3 the length of the body cavity	0.37-0.46	m	III
Ovary extending a little over 2/3 the length of the body cavity	0.46-0.56	m	IV
Ovary extending over the entire length of body cavity	0.57-0.81	M	V
Ovary extending over the entire length of body cavity	0.57-0.81 0.57-0.81	M M	VI(a) VI(b)
Shrunken ovary about 1/2 the length of abdominal cavity	..	S	VII

^{1/}
Im - Immature
m - Maturing
M - Mature
S - Spent fish

Table IV
 Key to the stages of sexual maturity of
 the male Indian mackerel (Rastrelliger kanagurta)
 (Pradhan and Palekar, 1956)

Extent of testes in the body cavity	State of maturity ^{1/}	Maturity stage
Testes less than half the length of the body cavity	Im	I
Testes slightly more than half the length of the body cavity	m	II
Testes extending to about 2/3 the length of the body cavity	m	III
Testes more than 2/3 the length of the body cavity	m	IV
Testes extending over the entire length of the body cavity	M	V
Testes extending over the entire length of the body cavity	M	VI
Testes comparatively much reduced in size	S	VII

^{1/} Im - Immature
 m - Maturing
 M - Mature
 S - Spent fish

- Coefficient of fecundity

Devanesan and John (1940) estimate an average of 94,000 eggs in the Indian mackerel.

3.1.6 Spawning

- Spawning seasons (beginning, end, peak)

The spawning season in India appears to be from May or June to September.

- Number of spawnings per year, frequency

It spawns in succession over a prolonged period and only a small percentage of ova mature each time giving that stage a speckled appearance described as "plum-pudding" stage. The number of batches discharged in a spawning season is not known, which makes it difficult to determine the number of eggs spawned during a season.

3.1.7 Spawning grounds

- Oceanic (surface, bottom)

Spawning grounds appear to be in deeper waters off Vizhingam (see 2.3).

3.1.8 Eggs: Structure, size, hatching type, parasites and predators

Range of ova diameters in mm: 0.038 - 0.27 immature; 0.28 - 0.56 maturing; 0.57 - 0.81 mature. The mature ova are transparent, measuring 0.88 mm - 0.90 mm, usually with a large oil globule. (Pradhan and Palekar 1956) The oil globule measures 0.23 mm in diameter. Sometimes 3 to 4 oil globulets may be present.

3.2 Larval history

3.2.1 Account of embryonic and juvenile life (prelarva, larva, postlarva, juvenile)

- Feeding

Bhimachar and George (1952) examined the gut content of a large number of young mackerel of sizes from 5.5 to 7.5 cm and found that their food did not differ radically from that of the adult. (See 3.4.2)

3.3 Adult history

3.3.1 Longevity

Probability of a fourth year-class is indicated from length frequency studies in Indian waters. Larger specimens (25-27 cm total length) which are caught in small numbers may be attributed to the fourth year-class.

3.3.2 Hardiness

(See 2.3)

3.3.3 Competitors

The oil sardine Sardinella longiceps on the west coast of India may be considered as competitor for food, as both are plankton feeders grazing on the same patches of plankton in inshore waters. Both are migratory fishes, moving in inshore waters in the same season.

3.3.4 Predators

Sharks, seerfish, ribbon fish and porpoises.

Mackerel shoals when attacked by seerfish scatter and when chased by sharks submerge with the head downwards in a compact mass. On porpoise attack, they dive and scatter.

3.3.5 Parasites and diseases

Trematode, cestode and copepod parasites were recorded from Indian mackerel. (Silas and Ummerkutty 1964)

3.3.6 Greatest size

Largest specimen recorded from Karwar was 30.7 cm (January 1955).

3.4 Nutrition and growth

3.4.1 Feeding (time, place, manner, season)

Chidambaram et al. (1952) studying the intensity of feeding in different size groups of Indian mackerel, found for all size groups two periods of intense feeding; one in October-December and the other in March-April. The absence of data for various size fishes in June, July and August did not allow the authors to draw any conclusion with regard to feeding habits during the spawning season.

The same authors found a distinct correlation between the maturity of the fish and its feeding intensity. From February to the middle of April when the mackerel were maturing, the feeding intensity is high. From the middle of April to June when the fish was advancedly mature, the feeding was low.

3.4.2 Food (type, volume)

India - west coast. Source: Central Marine Fisheries Research Institute, India from 1957 to 1962).

Mackerel has been found to subsist mainly on phytoplankton and zooplankton, the common items of food being Coscinodiscus, Dinophysis peridinium, Pleurosigma, Chaetoceros sp., Fragilaria oceanica, Thalassiothrix frauenfeldi, Nitzschia seriata, Skeletonema costatum, Thalassionema among the phytoplankters and tintinnids Evadne, Penilia, Cypris larvae, cladocerans, dinoflagellates, copepods like Oithona spp., Acrocalanus spp., Temora turbinata, Schmackeria serricaudata, Euterpina acutifrons, Labidocera, Acartia, Eucalanus and Squilla larvae, Alima larvae, gastropod larvae, bivalve larvae and fish post larvae among the zooplankters.

1957 - 1958 season: At Mangalore it was observed that active feeding takes place during October-December. Food consisted of zooplankton, dominated by copepods.

1958 - 1959 season: The volume of stomach contents was found to be high in November at Mangalore. Contents were mostly copepods.

1959 - 1960 season: The main items observed in the stomach contents were copepods, cladocerans and larval bivalves among zooplankton and Coscinodiscus among phytoplankton at Mangalore. At Calicut the stomachs (of fish 204-231 mm) were full in most cases, mainly of copepods. Phytoplankton contributed only a minor portion of food, chiefly by species of Dinophysis, Coscinodiscus, Peridinium and Pleurosigma. Large number of tintinnids were also seen. Other food items were crustacean eggs and larvae, bivalve larvae and cladocerans. At Vizhingam mackerel fed exclusively on planktonic organisms. In the first and last quarters zooplanktonic forms like copepods, Squilla larvae, prawn larvae, pelecypod larvae and Acetes sp. formed important constituents and in the second

and third quarters the phytoplanktonic fraction constituted the major item of their food.

1960 - 1961 season: In June, July and August the stomach contents at Karwar had diatoms. Chaetoceros sp., Fragilaria oceanica, Thalassiothrix frauenfeldi and Nitzschia seriata were found abundantly. Samples from offshore collections had dinoflagellates and many zooplankton elements. At Mangalore phytoplankton was dominant from April to August and zooplankton (Evadne, Penilia and copepods) was dominant from August to March. At Cannanore mackerel was found to feed on planktonic organisms with two peak periods of feeding in September-November and January-March. Generally phytoplankton dominated over zooplankton although the latter was dominant in certain months. At Ernakulam active feeding was observed from October to March, copepods predominated. Variety of diatoms and dinoflagellates were also met with. Juvenile mackerel (150-160 mm) in June fed exclusively on fish postlarvae. At Vizhingam both phyto- and zooplankton were noticed in gut contents. Phyllosoma larvae, Alima larvae, Cypris larvae, copepods, crustacean remains, bivalve larvae, gastropod larvae, Skeletonema costatum and Nitzschia were observed. At Porto Novo (east coast) feeding was intense and indiscriminate throughout the season during day as well as night. Gut contents largely reflected the composition of inshore plankton and its fluctuations.

1961 - 1962 season: At Karwar intensive feeding was observed in April. During April to August phytoplanktonic elements were prominent. Dinoflagellates cladocerans and copepods like Oithona spp., Acrocalanus spp., Temora turbinata, Schmackeria serricaudata and Euterpina acutifrons formed the main food during the post monsoon months. Scarcity of these food elements in the plankton may be one of the reasons for the failure of the fishery. At Mangalore in October, cladocerans, Evadne tergestina and Penilia avirostris were dominant. Copepods were dominant in other months. At Cannanore the phyto- and zooplankton formed the main food. At Calicut copepods formed the main food throughout the year. Labidocera, Acartia and Temora formed the major part of food in the early half of the year and Temora, Labidocera and Eucalanus in the latter half. Other items of food were Evadne, Penilia, crustacean eggs, Lucifer, tintinnids, bivalve larvae, Pleurosigma and Coscinodiscus.

The food consisted of copepods, other crustaceans, Alima larva, Cypris larva, Skeletonema costatum, Thalassiothrix, Nitzschia and Thalassionema at Vizhingam. Examination of stomach contents of mackerel from trawl catches at Bombay has shown presence of foraminiferan shells and sand grains.

3.5 Behaviour

3.5.1 Migration and local movements

In Karwar, India according to Pradhan (1956) with northeasterly winds shoals enter inshore waters.

Shoals usually move along the current of water at high tide. When there is a strong easterly wind mackerel shoals come close to the shore through deeper layers of water.

It was observed that mackerel shoals move in semicircular or arrow-head formations.

It may be inferred that mackerel shoals move at a speed of about 8 to 10 nautical miles per hour. In the Malaya Peninsula shoals move at 3 knots per hour.

Hardenberg (1955) states that the mackerels tend to follow the highest densities of plankton as has been indicated on the west coast of Borneo and probably off the west coast of Malacca.

Indonesia - Hardenberg gives the following information: "In the case of the oceanic mackerel one instance of migration is fairly well-known and this is in the Java Sea where the situation is briefly as follows: At the end of the west monsoon a stock of oceanic Rastrelliger is present. At the beginning of the east monsoon the waters of the Java Sea begin to flow in a westerly direction and the Rastrelliger moves off in a westerly direction and disappears. After some weeks a new stock enters the Java Sea through its eastern entrance. At the end of the east monsoon the

reverse happens and two new stocks enter the Java Sea, one from the northwest out of the South China Sea and one from the southwest out of the Indian Ocean.

"This study was based on the migration of Decapterus but mackerels follow the same pattern closely, generally being one to two weeks behind."

The possibility of actual spawners moving out of the intensively fished area is indicated by observations at Porto Novo. Appearance of mackerel in inshore waters depends to some extent on the availability of the food elements in the inshore plankton and one of the contributing factors responsible for the failure of the mackerel fishery in the year 1961-1962 at Karwar may be the scarcity of food elements in plankton. During September-January moderate temperature, pH and salinity prevail in the inshore waters (Karwar) during which time mackerel appears in shoals along the coastline. A survey of R.V. VARUNA in the Mangalore-Calicut zone in February 1962 revealed traces of shoals in waters up to 20 m depth, but beyond this range there were no traces.

During the 1961-1962 season occurrence of mackerel was recorded in the trawl catches off the Bombay and Saurashtra coasts in November and December.

3.5.2 Schooling

In Karwar, India, (Pradhan 1956) the size range in a single mackerel shoal is very small and the individuals collectively present a striking uniformity of size. This suggests that mackerel of different size groups move in separate shoals and the range of size in the same shoal is not significantly large.

A record catch of 2,100,000 mackerel in one net was noticed on 1.12.1957 at Karwar.

3.5.3 Reproductive habits

No segregation of sexes.

4 POPULATION (STOCK)

4.1 Structure

4.1.1 Sex ratio

Generally, males and females were about equal in number in the commercial catches (data from 1955-1961 from the west coast of India). (see Table V)

Table V
Sex ratios on the west coast of India^{1/}

Seasons	Localities	Ratios
1955 - 1956	Calicut	About 50:50
1956 - 1957	-	50:50 but males outnumbered females during spawning period
1957 - 1958	-	No information available
1958 - 1959	Karwar	50:50
1959 - 1960	Karwar	About 50:50
1960 - 1961	Cannanore Ernakulam	50:50 Ratio fluctuated but females were slightly more numerous than males

^{1/} Central Marine Fisheries Research Institute
India (1955-1961)

4.1.2 Age composition

Mackerel of the first, second and third year-classes are represented in the commercial catches. Fish of the fourth year-class are rarely represented.

Mackerel appears to attain a length of 14-15 cm in the first year. The commercial size of 19 - 21 cm may be 2 years old (immature). By the time they begin to spawn, they are three years old (23-24 cm). Probability of a fourth year class (25-27 cm) is also indicated. Specimens up to 30.2 cm have been recorded at Vizhingam in the 1956-1957 season. Studies at Mandapam (1957-1958) indicated that individuals below 22 cm showed clear annual rings. It seems probable that these rings are spawning marks, which may be

useful not only in age and maturity studies but also in radiation studies in view of the reported variation in size distribution and spawning period of the species on different parts of the Indian coast. The trend of occurrence of rings of scales was more or less the same as above at Calicut during the 1960-1961 season.

4.1.3 Size composition

The general size range varies from 3.5 to 29.5 cm in different months.

4.2 Size and density

4.2.1 Average size

See 4.2.2.

4.2.2 Changes in size

Karwar (India) - Pradhan (1956)

1948 - 1949 season: Dominant size-class from December 1949 was 20.5 cm.

1949 - 1950 season: Three dominant classes, 17.5 cm; 18.5 cm and 19.5 cm constituted the fishery at various intervals. The 19.5 cm group persisted throughout the season with exception of October and December.

1950 - 1951 season: October 1950: Dominant size-group, 19.5 cm entered the fishery; in November, increased to 20.5 cm and disappeared in December. The second group entered the fishery in November 1950 and the dominant size-class was then 17.5 cm, increasing to 20.5 cm in December, 21.5 cm in January 1951 and 22.5 cm in February and March.

1951 - 1952 season: Dominant size-class in October 1951 was 19.5 cm, increasing to 20.5 cm in November and persisting throughout the season.

1952 - 1953 season: Dominant size-class in October was 17.5 cm which increased to 19.5 cm in November and persisted till March 1953. The larger group, 22.5 cm, which entered the fishery in October increased to 23.5 cm in November and persisted in small numbers until December.

West coast of India; Source: Central Marine Fisheries Research Institute, India, (1953-1962)

1953 - 1954 season: The 19.5 cm size-class was dominant.

The 22-23 cm size group at Mandapam (east coast) and 19.5 cm size class at Karwar were dominant in the fishery.

1954 - 1955 season: The total size range was 11.3 to 23.0 cm.

At Karwar, during April-May the size range was 11.3-16.4 cm. In July the range varied between 12.9-25.0 cm the dominant class being 22 cm. In August the size range was 15.1-23.0 cm and in September 13.1-20.1 cm, the dominant class in the latter period being 14 cm. A point of special interest is the occurrence of young mackerel of 5 cm in shore seines at Madras (east coast).

1955 - 1956 season: Size range was 19.0-25.0 cm.

At Calicut during November-December the size range varied from 19.0-25.0 cm.

1956 - 1957 season: Size range was 9.8-26.2 cm the dominant groups being 14-15 cm, 18 cm, 16-19 cm, 19-21 cm and 23 cm at various places.

There was much inconsistency of size in the fish contributing to the fishery at Mandapam (east coast). Bulk of the commercial landings at Calicut were composed of 16-19 cm group and 19-21 cm group in the early and latter half of the peak season (September-October). Fish measuring more than 24 cm were notably absent. At Mangalore the size range was 19-21 cm. At Karwar the minimum and maximum sizes were 9.8 cm and 26.2 cm respectively. Three dominant size groups in the fishery were 14-15 cm, 18 cm and 23 cm. At Vizhingam, juveniles (11-13 cm) and spawners (24-27 cm) were encountered, the commercial size group being 19-21 cm. Spawners of the size group 24-27 cm were recorded in the fishery for the first time in India. Postlarval mackerel 11-22 mm were also recorded from October to June, in large numbers for the first time.

1957 - 1958 season: The dominant size groups were 13 cm, 18 cm, 20.5 cm, 21.5 cm and 23 cm in different months at different places. Young mackerel (3-6 cm) were caught.

At Calicut two size groups, 6.5-17.5 cm and 16-17 cm entered the fishery in August. In September modal size was 18 cm. In November the dominant size group was 21.5 cm and in December to February, 20.5 cm. Mackerel caught by trawlers at Ernakulam in May measured 21-24 cm with the mode at 23 cm. Juvenile mackerel appeared in July. Size groups 8-10, 12-13 and 16-18 cm were dominant in July, August and September. The fishery from November to March was sustained by the 18-20 cm size groups. The size range at Karwar was 12.2-25.9 cm the dominant size group being 21.5 cm which persisted throughout the season. At Mangalore in October the dominant size group was 18.4-19.5 cm and at the close of the season, it was 21.5-22.0 cm. During January-March, large mackerel 23.0-27.2 cm were recorded in the Netravati

estuary. At Vizhingam the total size range was 18-31 cm with the 23-24 cm group dominating, juvenile mackerel varying in size between 10-17 cm with the 13 cm group dominating were also caught. On 29.6.1957 young mackerel (3-6 cm) were caught only from 15-18 fathoms.

1958 - 1959 season: The total size range was 4.0 - 24.5 cm. Prominent size groups were 19.0 - 20.0 cm and 21.5 cm.

At Karwar, in October and November the fishery was composed of 19.0 and 20.0 cm groups. From October to March there was a shift in the mode from 19.0 to 22.0 cm. At Mangalore large size fish were caught (21.0-21.9 cm). At Calicut the fishery was contributed by one dominant class (21.5 cm) which persisted throughout the season. Juvenile mackerel (16.0 cm) were recorded in September. At Cochin the 20.0-22.0 cm group in April 1958 and from September to January 1959 the 19.0-21.0 cm group mainly supported the fishery. At Vizhingam the size range was 4.0-24.0 cm. Adults of 22.5-24.5 cm dominated in the last quarter. At Mandapam (east coast) the size range varied from 20.7-31.2 cm in April, 22.0-23.6 cm in May and 19.1-24.4 cm from November to February. At Porto Novo (east coast) the size of mackerel varied from 14.0-17.0 cm (August-September) and 20.0-24.0 cm (January to March).

1959 - 1960 season: Size composition varied from 4.5 - 29.5 cm at different places. Dominant size groups were 18.0 cm, 19.0 cm, 20 cm, 20.0 - 21.0 cm. Juveniles were recorded (4.5 - 7.0 cm).

The fishery at Karwar was composed of immature fish of 17.0-22.0 cm. Young mackerel of 10.0-13.0 cm occurred frequently during April, May, June and August. The 20.0-21.0 cm group dominated. At Mangalore, the fishery was supported by the 19.0-19.4 cm size group in October, and 22.0-22.4 cm in March. At Calicut the 12.5 cm in August, 16.5 cm in September, 18.5 cm in October, 20.5 cm in November-December and 21.5 cm in January to March. At Ernakulam in April and May fish ranging in size from 20.0 to 23.0 cm with modal length 22.0 cm were caught in moderate quantities. In October, fish with modal lengths 18.0 and 19.0 cm were predominant, which increased to 21.0 cm by March. Smallest mackerel (5.6 cm) was collected in August from the 20

fathom area. At Neendakara the size range was 14.9-24.9 cm in May. At Vizhingam in the first quarter, two size groups, 5.0-6.0 cm and 9.0-14.0 cm were common. Adult fish of 22.0-25.0 cm were recorded as stray specimens. In the second quarter the size classes 8.0-12.0, 13.0-15.0 and 16.0-19.0 cm entered the fishery. Bigger fish of size range 14.0-22.0 cm with modal sizes at 18.0 and 20.0 cm were recorded during the third quarter. The size range was 20.0-29.5 cm in the last quarter. Juveniles of 4.5-7.0 cm were also noticed at the end of the period. At Porto Novo (east coast) the bulk of the catches were constituted by spawners of 20.0-24.0 cm size.

1960 - 1961 season: Total size range was 4.5 - 28.0 cm with the 12.0 cm, 13.0 cm, 16.0 cm, 19.0 cm, 20.0 cm and 21.0 cm groups predominating.

At Karwar the fishery was mainly dependent on 19.0-21.5 cm size, the total range being 15.0-25.5 cm. Large mackerel occurred from April to August. At Mangalore, size range of fish was from 12.0-24.4 cm. At Cannanore the fishery in the first quarter was sustained by 11.0-14.0 cm group (mode at 12.0 cm), second quarter by juveniles (11.0-12.0 cm) and medium sized mackerel (14.0-19.0 cm). In the third and fourth quarters the fish ranged in size between 18.0-23.0 cm with mode at 21.0-22.0 cm. At Calicut fish of the 21.5 cm group persisted throughout the season. At Ernakulam in April and May the modal size was 21.0 cm. Juveniles (11.0-15.0 cm) were recorded in trawl catches in May from the 8-10 fathom area off Cochin. The dominant size groups in July-August were 13.0 and 16.0 cm, in September 19.0 cm, in October-November 20.0 cm and December to March 21.0 cm. At Vizhingam the size range of fish was 4.5-28.0 cm. At Porto Novo (east coast) the dominant size of fish was 19.0-20.0 cm.

1961 - 1962 season: Size range was 3.5 - 27.0 cm. The 16.5 cm, 18.5 cm and 22.5 cm groups were dominant.

The fishery at Karwar was contributed by two groups of the size 18.0-19.5 cm, and 22.5-23.5 cm. At Mangalore in April-May the range in size was 20.5-23.9 cm. In October it was 14.5-17.9 cm. During December-January the groups 17.0-17.4 cm and 17.5-17.9 cm were dominant. From January to March, the common size in Netravati estuary was 20.5-25.9 cm. At Cannanore the dominant size was 22.5 cm in the first and second quarters and in the third quarter the range was 17.5-18.5 cm. The 22.5-24.5 cm group was rare in the

fishery. At Calicut the commercial landings were made up of juveniles and medium sized (15-17 cm) fish. In October the dominant size was 16.5 cm which persisted till the end of December. In January 1962 dominant size was 18.5 cm. From April to September large fish (21.3-25.8 cm) with 22.5 cm as the dominant size were caught. At Vizhingam the commercial catches consisted of fish in the size range 3.5-27.0 cm. At Porto Novo (east coast) from April to June the range was 180-200 cm. In September the modal size was 160 cm.

Manacop (1955) states that *R. brachysoma* reaches a maximum length in the Philippines of 22.0 cm and a weight of about 200 g. The average size taken commercially is about 18.0 cm and the average weight 100 g. The average size of the commercial catch of *R. kanagurta* is about 25.0 cm and 230 g. With a maximum of about 30.0 cm and 380 g.

5 EXPLOITATION

5.1 Fishing equipment

5.1.1 Fishing gear

Philippines

Adult chub mackerels (*R. brachysoma* and *R. kanagurta*) are caught mainly by fish corral (Ibaklad) in Malampaya Sound and by purse seines (Italakop) in Manila Bay. The basnig, sapyaw and sinsoro, which capture fish with the aid of light are also extensively used for catching juvenile and intermediate sizes. Explosives are effectively used in the catching of alumahan *R. kanagurta* on the offshore reefs and shoals by naked divers working from a "mother" fish-carrier vessel. (Philippines Fisheries Handbook 1952)

India - west coast

See Table VI.

Thailand and Cambodia

As stated by Durand (1949) large quantities of Indian mackerel are caught in fixed traps, established on the muddy bottom in depths varying from four to fifteen metres.

Ceylon

The slenderer variety in Ceylon is known as kumbala and the wider bodied variety as holla. It has not yet been possible to determine to which of these groups the juvenile forms belong. The juvenile forms often have other local names. The catches of holla are higher along the south coast. In general the heaviest landings are made with the beach seine but a great deal of angling with handlines, bearing from 15-25 hooks in a cluster, is carried on off the south coast from boats which hover over the shoals of holla for the purpose. Brightly shining artificial lures, often made of lead, are utilised. They are also taken on rod and line using a little drop-shaped bead of lead with a barb as lure. (de Zylva 1956)

5.1.2 Fishing boats

India

See Table VI. The Pandi carries only the rampan net and a crew of 16 to 20 and its size is 45 x 10 x 4 feet. The doni is a smaller boat used as a

scout boat for sighting mackerel shoals or for removing mackerel from an impounded area. Manned by a crew of 6 to 8 and propelled with both oars and sails its size is 24 x 3 x 2 feet.

5.2 Fishing areas

5.2.1 General geographic distribution (Fig. 5)

Somalia

Rastrelliger kanagurta is often found in large schools at the surface.

India - west coast

The most important economic food fish of this coast from Ratnagiri in Bombay State to Quilon in the south.

Chopra (1951) divides the important mackerel fishing areas on the west coast into four zones according to the different types of boats and nets employed to suit the physical characters of the coast-line. These areas from north to south are: (1) Konkan - from Rajeewade in the Ratnagiri District to the mouth of Terkhol creek; (2) North Canara - from Majali on the southern boundary of Goa to Bhatkal near the southernmost coastal limit of Bombay State; (3) South Canara - from the southern boundary of Bombay State to the mouth of Baliapatam river near Cannanore, and (4) Malabar - from Cannanore in the north to the southern part of Travancore. The chief mackerel fishing centres on the west coast are - Ratnagiri, Malvan, Karwar, Malpe, Tellichery, Calicut and Cochin.

India - east coast

The northern limit of the occurrence of this species is Ganjam. Chopra (1951) states that "except for the sporadic occurrence of mackerel, there is no regular fishery of this fish on the east coast".

Ceylon

Coastal waters, Gulf of Mannar and trawling grounds.

Cambodia

Neighbourhood of the Bay of Kampong-Som, Cone Island and Kaskapik.

Indonesia

Southern coast of Borneo and north

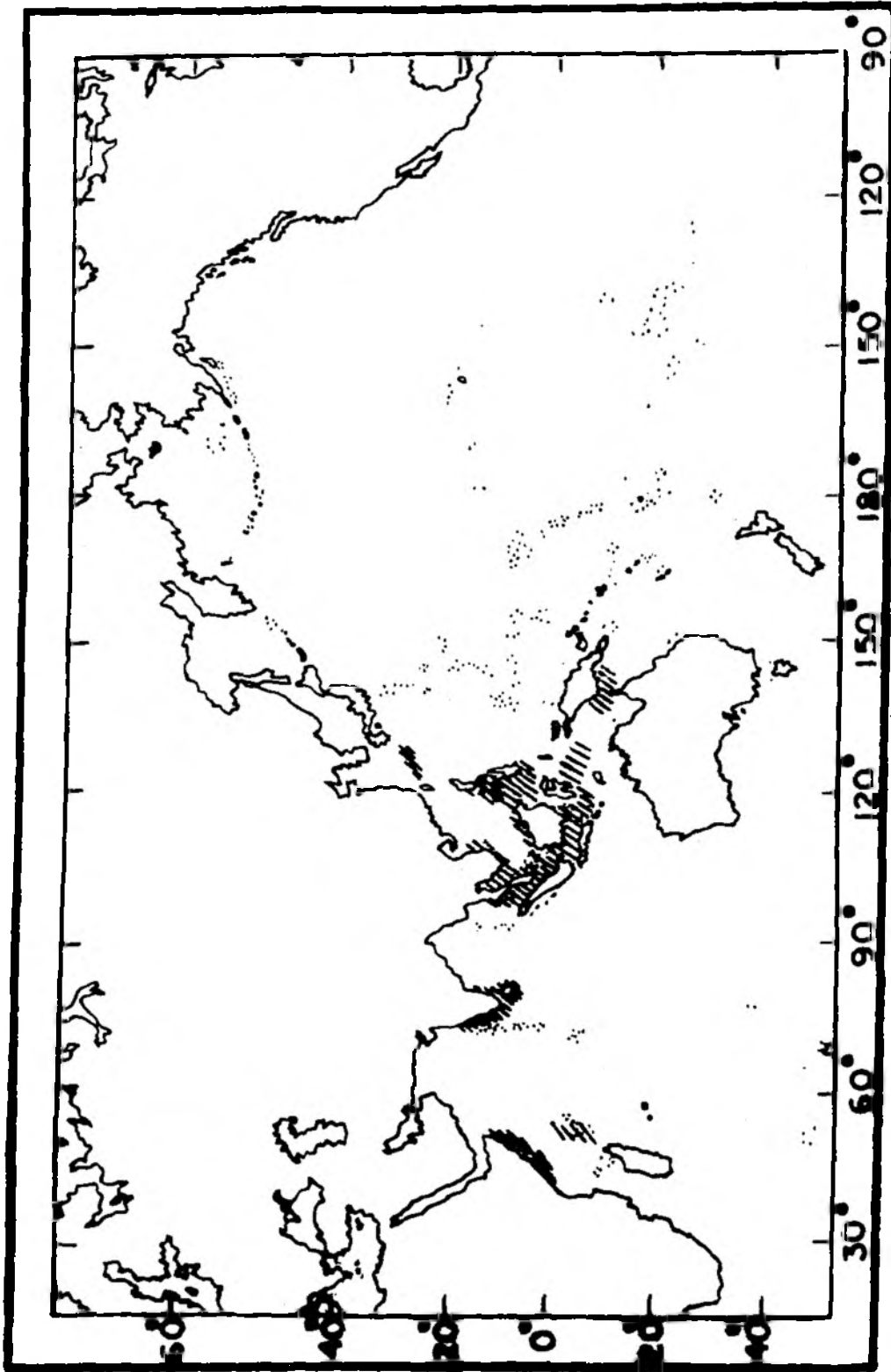


Figure 5. Fishing areas of the genus Rastrelliger

Table VI
Types of fishing gear and craft
India

Fishing area	Type of boat	Type of net	Vernacular name
Konkan area	<u>Pandi</u> ; <u>Hodi</u> - both are provided with an outrigger equipment	Shore seine Drift net Cast net	<u>Rampan net</u> <u>Pettle bale</u> <u>Pag</u>
North Canara area	<u>Pandi</u> ; <u>Doni</u> - similar to above with outrigger	Shore seine Drift net Cast net	i. <u>Rampan net</u> ii. <u>Yendi</u> or <u>Payawada</u> <u>Patta bale</u> <u>Pag</u>
South Canara area	<u>Pandi</u> (with outrigger)	Shore seine Drift net Cast net	<u>Rampan net</u> <u>Pattae balai</u> <u>Deb balai</u>
Malabar area	Dugout canoes	Seine net Gilling net	i. <u>Odam vala</u> , also called <u>Peru vala</u> and <u>Paithu vala</u> ii. <u>Aiyla Kolli vala</u> <u>Aiyla chala vala</u>

coast of Sumatra.

Japan

Neighbourhood of the Ryukyu Islands.

Philippines

The principal fishing areas of young and adult *R. kanagurta* are: eastern and northwest Palawan and vicinities; north-east Palawan, including Cuyo group; southern Zamboanga and Sulu Archipelago; Visayan Sea, and of *R. brachysoma*: Manila Bay, Ragay Gulf, Southwest Samar, Estancia, Iloilo, Gigantes and Bantayan Islands, northern Negros, Malampaya Sound and vicinity; Pantao and Malakbala, Albay Province; Mercedes, Camarines Norte.

5.2.3 Depth ranges

Mackerel fishery is usually confined to inshore waters but fish have been recorded in the trawl catches off Bombay and Saurashtra coasts, in November and December during the 1961-1962 season. A survey by R.V. VARUNA in the Mangalore-Calicut zone in February 1962 revealed traces of shoals in waters up to 20 m depth but not beyond.

Generally, the changes in depth at which mackerel are caught depend on the nature of coastline, the time or season of fishing and the type of net operated. The depth may vary from 2 to 12 fathoms or even more. Mackerel were caught in even deeper waters off Porbandar in trawl operation. Along the Kanara and Konkan coast up to Ratnagiri, where the bottom of inshore waters is sandy or muddy, the shore-seine-Rampan net is operated in 2-4 fathoms or within a range of a mile and a half. During the rainy season a smaller shore-seine is operated in one or two fathoms. Gill nets and boat-seines on the Malabar coast in particular, are not usually operated so close to the shore or in shallow waters.

5.3 Fishing seasons

5.3.1 General pattern of fishing season

The mackerel season depends on the concentration of shoals in inshore waters where they are intercepted and caught.

5.3.2 Duration of fishing season

Chidambaram and Venkataraman (1946) state that the Indian mackerel fishery on

the west coast of India extends from September to April, prior to the outbreak of the southwest monsoon. At Karwar and along the Kanara coast as indicated by Pradhan (1956) it is from October to February and may, at times, extend to March. The mackerel shoals subsequently break up, resulting in poor catches in April, and practically disappear from the shores of Karwar during May. In the rainy season, June to end of September, they are occasionally caught in small numbers in inshore waters within a range of about half a mile from the shore. Thus the duration of fishing season may vary from coast to coast. On the Malabar coast, it may be 5-7 months and on the Kanara and Konkan coast up to Ratnagiri 4-6 months.

5.3.3 Dates of beginning, peak and end of season

India

On the Malabar coast, the season begins in August-September, with a peak in November-December and ends in February or March. On the Kanara and Konkan coasts, it may begin some time in October with a peak in November-December, closing abruptly in February-March. A secondary peak of a short duration was noted towards the end of the season, February-March on the west coast.

Cambodia

As indicated by Durand (1949) the mackerel appears on the coast towards the end of October in the neighbourhood of the Bay of Kampong-Som; a month later near Cone Island and Kaskapik. It remains there until February, a period when the females are ripe and ready to spawn.

Philippines

See Tables VII and VIII.

Ceylon

Large shoals of *R. kanagurta* normally occur on the west coast of Ceylon where they are caught in considerable numbers in the beach seine in the November-February period, and on the east coast almost throughout the year, with peaks in September and December-April. Catches of the inshore species are highest on the south coast in the December-February period.

Table VII
Principal fishing areas and seasons of the
young and adult "hasa-hasa" (R. brachysoma)
(Philippines)

Fishing Areas	Fishing Young	seasons Adult
Manila Bay	Throughout the year	May to December
Ragay Gulf	March to September	December to May
Southwestern Samar	November to January	February to May
Estancia Iloilo	March to June	May to October
Gigantes and Bantayan Islands	March to May	April to October
Northern Negros	May to June	June to August
Malampaya Sound and vicinity	April to May	May to September
Pantao and Malakbala, Albay Province	April	October to May
Mercedes, Camarines Norte		May to September

Table VIII
Principal fishing areas and seasons of the
adult "alamahan" (R. kanagurta)
(Philippines)

Fishing areas	Fishing season
Eastern and northwestern Palawan and vicinities	December to June
Northeastern Palawan, including Cuyo group	April to November
Southern Zamboanga and Sulu Archipelago	December to May
Visayan Sea	April to October

5.3.4 Variation in time or duration of fishing season

In some years the season was very short, lasting for 3-4 months.

5.3.5 Factors affecting fishing season

The monthly total catch of mackerel appears to be more influenced or governed in Karwar (Pradhan 1956), by the dominant size-class or classes, than by the actual number or pieces of Rampan net in operation during the month. In other words, the frequency of appearance of mackerel shoals in inshore waters and probably the size of a shoal itself, appear to be related in some unknown manner to the dominant size-class of the month or season.

The following points are noteworthy with respect to Indian mackerel:

- a) High mortality of eggs
- b) Removal of potential spawners and the consequent effect on recruitment
- c) Scarcity of edible forms of planktonic organisms which constitute the major food elements of mackerel
- d) Hydrographic factors such as temperature of sea water, salinity, pH, etc.

- e) Movement of mackerel of different size groups in inshore waters has been found to be in direct relation to hydrographic factors. Small size groups (12-16 cm) are usually abundant in the period of low salinity and temperature (July-September) whereas spawning fish can adapt themselves to high temperature and salinity.

5.4 Fishing operations and results

5.4.3 Catches

Particulars of total annual yield of mackerel in India during 1950-1962 are as follows:

Year	Catch (metric tons)
1950	89,163
1951	103,900
1952	78,014
1953	70,754
1954	28,258
1955	22,795
1956	16,426
1957	89,006
1958	123,282
1959	62,198
1960	133,655
1961	34,485
1962	29,103

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SYNOPSIS OF FISHERIES BIOLOGICAL DATA

This is one of a series of documents issued by FAO and CSIRO concerning species and stocks of aquatic organisms of present or potential economic interest. The primary purpose of the series is to make existing information readily available to fishery scientists according to a standard pattern, and by so doing also to draw attention to gaps in knowledge. It is hoped that synopses in the series will be useful to other scientists initiating investigations of the species concerned or of related ones, as a means of exchange of knowledge among those already working on the species, and as the basis for comparative study of fisheries resources. They will be brought up to date from time to time, as further information becomes available. It is, therefore, recommended that they be filed in loose-leaf folders; pagination begins anew with each chapter, so that partial revisions may be made.

The relevant series of documents are:

FAO	Fisheries Synopsis No. (replacing, as from 1.1.63)	Fib/S
FAO	Fisheries Biology Synopsis No.	FB/S)
	and	
CSIRO	Fisheries Synopsis No.	DFO/S

Synopses in these series present data compiled according to a standard outline described in FB/SI (1962). Steps are being taken to form an advisory association comprising representatives of the participating organizations, authors of synopses and other collaborators.

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Rome, Italy

Consolidated lists of species or groups covered by synopses issued to date or in preparation will be issued from time to time. Requests for copies of synopses should be addressed to the issuing organization.

The following synopses in this series have been issued since January 1963:

Fib/S24 (Rev. 1)	Synopsis of biological data on European Grayling <i>Thymallus thymallus</i> (Linnaeus) 1758	March 1964
FB/S25	Synopsis of biological data on hilsa <i>Hilsa ilisha</i> (Hamilton) 1822	January 1963
Fib/S26	Synopsis of biological data on anchovy <i>Engraulis encrasicolus</i> (Linnaeus) 1758 (Provisional version)	February 1963
Fib/S27	Synopsis of biological data on sprat <i>Sprattus sprattus</i> (Linnaeus) 1758 (Provisional version)	February 1963
DFO/S1	Synopsis of biological data on the grey mullet <i>Mugil cephalus</i> (Linnaeus) 1758	June 1963
Fib/S28	Synopsis of biological data on pike-perch <i>Lucioperca lucioperca</i> (Linnaeus) 1758	March 1964
Fib/S29	Synopsis of biological data on Indian mackerel <i>Rastrelliger kanagurta</i> (Cuvier) and short bodied mackerel <i>Rastrelliger brachysoma</i> (Bleeker) 1851	January 1965